MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2017/2018

ECT2036 – CIRCUITS AND SIGNALS

(All sections / Groups)

21 OCTOBER 2017
9.00 a.m. – 11.00 a.m.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 8 pages including cover page with 4 Questions only.

2. Attempt **ALL** the questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the Answer Booklet provided.

4. Appendix is provided after the question pages.

Question 1

a) For the circuit as shown in Figure Q1 (a)

(i) Draw simplified directed network graph with proper branch numbering

(ii) Determine the number of tree branches and links with proper graph representation

(iii) Locate fundamental cut-sets

(iv) Write down the nodal incidence matrix

(v) Locate the fundamental loops and then determine the fundamental loop matrix.

[4+3+3+4+5 marks]

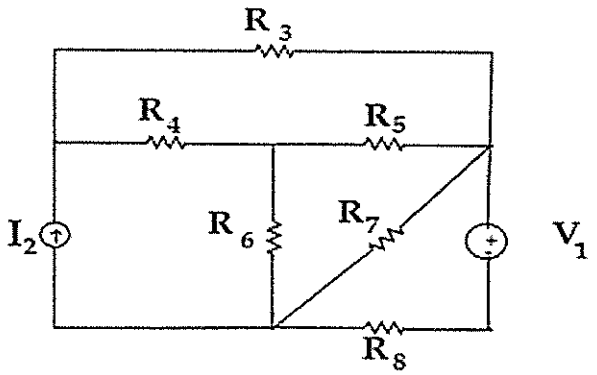

Figure Q1(a)

(b) Determine the Laplace transform of function

(i) f(t)= $\frac{d}{dt}[2 + e^{-3t}]$

(ii) $f(t) = \delta(t-2) + e^{-2t}\cos(2t)\,u(t)$ [4+2 marks]

Continued...

Question 2

a) Determine whether given function $f(t) = Ae^{i\omega_0 t}$ is power signal or energy signal. Where, A is constant [5 marks]

b) (i) Plot unit step function which is mathematically represented as;

$$f(t) = \begin{cases} 0, & \text{if } t < a \\ 1, & \text{if } a \leq t \leq b \\ 0, & \text{if } t \geq b \end{cases}$$

[3 marks]

(ii) Evaluate $\int_{-\infty}^{\infty} \sin(t)\delta(2t - \pi)dt$ [4 marks]

c) (i) The unit impulse response of a linear time invariant continuous-time system is $h(t) = e^{-5t}u(t)$
Find the system output for the input $\cos(t)u(t)$ [5 marks]

(ii) If $x(t) = e^{-at}u(t)$ and $h(t) = e^{-bt}u(t)$, determine y(t) by evaluating convolution integral. [5 marks]

(ii) For a=2 and b=3 in part (ii), plot y(t). [3 marks]

Continued...

Question 3

a) The following two equations show the state space representation of a circuit.

$$\begin{bmatrix} \dot{v}_1 \\ \dot{v}_2 \end{bmatrix} = \begin{bmatrix} 0 & -0.4 \\ 0.4 & -0.8 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix} + \begin{bmatrix} 0.4 \\ 0 \end{bmatrix} v_{in}$$

$$\begin{bmatrix} v_{out1} \\ V_{out2} \end{bmatrix} = \begin{bmatrix} 1 & -1 \\ 2 & 3 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} v_{in}$$

Determine the transfer function $H(s)$.

[13 marks]

b) Derive the state and output matrix equations for the circuit as shown in Figure Q 3 (b). $v_s(t)$ and $v_o(t)$ are the input and output voltages, respectively.

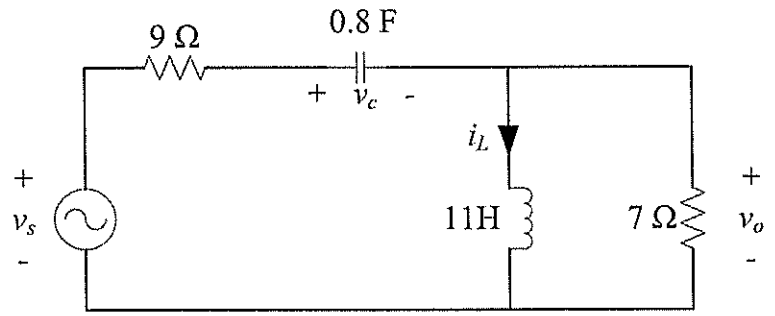

Figure Q3 (b)

[12 marks]

Continued...

Question 4

a) Using Hurwitz criterion, examine whether the following polynomial is Hurwitz.

$$P(s) = 12s^5 + 12s^4 + 77s^3 + 29s^2 + 22s + 2$$

[7 marks]

b) Implement the following function using Foster 1st Method.

$$Z(s) = \frac{s(s^2 + 9)}{s^2 + 4}$$

[10 marks]

c) An engineer has been given a task to design a low pass filter with the following specifications,

Maximum pass-band attenuation, $A_P = 2dB$
Minimum stop-band attenuation, $A_S = 75dB$
Maximum pass-band frequency, $f_p = 22kHz$
Minimum stop-band frequency, $f_s = 180kHz$

Compare the filter order n and constant ε (at stop band) required to implement the design with (i) Butterworth and (ii) Chebyshev.

[8 marks]

Continued...

APPENDIXES

Chapter 1:

Nodal Analysis	**Mesh Analysis**
1. $Y_N = AYA^T$ 2. $e_{\text{Node}} = -Y_N^{-1}A(I+YE)$ 3. $e = A^T e_{\text{Node}}$ 4. $i = Ye + (I+YE)$	1. $Z_M = BZB^T$ 2. $i_{\text{Mesh}} = Z_M^{-1}B(E+ZI)$ 3. $i = B^T i_{\text{Mesh}}$ 4. $e = Zi - (E+ZI)$
Fundamental Cutset Analysis	**Fundamental Loop Analysis**
1. $Y_C = CYC^T$ 2. $e_{\text{Twig}} = -Y_C^{-1}C(I+YE)$ 3. $e = C^T e_{\text{Twig}}$ 4. $i = Ye + (I+YE)$	1. $Z_L = DZD^T$ 2. $i_{\text{Link}} = Z_L^{-1}D(E+ZI)$ 3. $i = D^T i_{\text{Link}}$ 4. $e = Zi - (E+ZI)$

Chapter 2:

Even signal: $f(t) = f(-t)$ or $f[n] = f[-n]$

Odd signal: $f(t) = -f(-t)$ or $f[n] = -f[-n]$

Energy content: $E = \lim_{T\to\infty} \int_{-T}^{T} f^2(t)dt$ or $E = \lim_{N\to\infty} \sum_{n=-N}^{N-1} f^2[n]$

Power content: $P = \lim_{T\to\infty} \frac{1}{2T} \int_{-T}^{T} f^2(t)dt$ or $P = \lim_{N\to\infty} \frac{1}{2N} \sum_{n=-N}^{N-1} f^2[n]$

Chapter 3: Laplace transform pairs

No.	*t*-domain function	*s*-domain transform
1.	$\delta(t)$	1
2.	$u(t)$	$1/s$
3.	$tu(t)$	$1/s^2$
4.	t^n	$\frac{n!}{s^{n+1}}$
5.	e^{-kt}	$\frac{1}{s+k}$
6.	$t^n e^{-kt}$	$\frac{n!}{(s+k)^{n+1}}$

7.	$\sin\omega t$	$\frac{\omega}{s^2+\omega^2}$
8.	$\cos\omega t$	$\frac{s}{s^2+\omega^2}$
9.	$e^{-kt}\sin\omega t$	$\frac{\omega}{(s+k)^2+\omega^2}$
10.	$e^{-kt}\cos\omega t$	$\frac{s+k}{(s+k)^2+\omega^2}$
11.	$t\sin\omega t$	$\frac{2\omega s}{(s^2+\omega^2)^2}$

Chapter 4: Interrelation of parameters

	z	y	h	g	$ABCD$	$abcd$
z	z_{11} z_{12} z_{21} z_{22}	$\frac{y_{22}}{\Delta y}$ $\frac{-y_{12}}{\Delta y}$ $\frac{-y_{21}}{\Delta y}$ $\frac{y_{11}}{\Delta y}$	$\frac{\Delta h}{h_{22}}$ $\frac{h_{12}}{h_{22}}$ $\frac{-h_{21}}{h_{22}}$ $\frac{1}{h_{22}}$	$\frac{1}{g_{11}}$ $\frac{-g_{12}}{g_{11}}$ $\frac{g_{21}}{g_{11}}$ $\frac{\Delta g}{g_{11}}$	$\frac{A}{C}$ $\frac{\Delta a}{C}$ $\frac{1}{C}$ $\frac{D}{C}$	$\frac{d}{c}$ $\frac{1}{c}$ $\frac{\Delta b}{c}$ $\frac{a}{c}$
y	$\frac{z_{22}}{\Delta z}$ $\frac{-z_{12}}{\Delta z}$ $\frac{-z_{21}}{\Delta z}$ $\frac{z_{11}}{\Delta z}$	y_{11} y_{12} y_{21} y_{22}	$\frac{1}{h_{11}}$ $\frac{-h_{12}}{h_{11}}$ $\frac{h_{21}}{h_{11}}$ $\frac{\Delta h}{h_{11}}$	$\frac{\Delta g}{g_{22}}$ $\frac{g_{12}}{g_{22}}$ $\frac{-g_{21}}{g_{22}}$ $\frac{1}{g_{22}}$	$\frac{D}{B}$ $\frac{-\Delta a}{B}$ $\frac{-1}{B}$ $\frac{A}{B}$	$\frac{a}{b}$ $\frac{-1}{b}$ $\frac{-\Delta b}{b}$ $\frac{d}{b}$
h	$\frac{\Delta z}{z_{22}}$ $\frac{z_{12}}{z_{22}}$ $\frac{-z_{21}}{z_{22}}$ $\frac{1}{z_{22}}$	$\frac{1}{y_{11}}$ $\frac{-y_{12}}{y_{11}}$ $\frac{y_{21}}{y_{11}}$ $\frac{\Delta y}{y_{11}}$	h_{11} h_{12} h_{21} h_{22}	$\frac{g_{22}}{\Delta g}$ $\frac{-g_{12}}{\Delta g}$ $\frac{-g_{21}}{\Delta g}$ $\frac{g_{11}}{\Delta g}$	$\frac{B}{D}$ $\frac{\Delta a}{D}$ $\frac{-1}{D}$ $\frac{C}{D}$	$\frac{b}{a}$ $\frac{1}{a}$ $\frac{-\Delta b}{a}$ $\frac{c}{a}$
g	$\frac{1}{z_{11}}$ $\frac{-z_{12}}{z_{11}}$ $\frac{z_{21}}{z_{11}}$ $\frac{\Delta z}{z_{11}}$	$\frac{\Delta y}{y_{22}}$ $\frac{y_{12}}{y_{22}}$ $\frac{-y_{21}}{y_{22}}$ $\frac{1}{y_{22}}$	$\frac{h_{22}}{\Delta h}$ $\frac{-h_{12}}{\Delta h}$ $\frac{-h_{21}}{\Delta h}$ $\frac{h_{11}}{\Delta h}$	g_{11} g_{12} g_{21} g_{22}	$\frac{C}{A}$ $\frac{-\Delta a}{A}$ $\frac{1}{A}$ $\frac{B}{A}$	$\frac{c}{d}$ $\frac{-1}{d}$ $\frac{\Delta b}{d}$ $\frac{b}{d}$
A B C D	$\frac{z_{11}}{z_{21}}$ $\frac{\Delta z}{z_{21}}$ $\frac{1}{z_{21}}$ $\frac{z_{22}}{z_{21}}$	$\frac{-y_{22}}{y_{21}}$ $\frac{-1}{y_{21}}$ $\frac{-\Delta y}{y_{21}}$ $\frac{-y_{11}}{y_{21}}$	$\frac{-\Delta h}{h_{21}}$ $\frac{-h_{11}}{h_{21}}$ $\frac{-h_{22}}{h_{21}}$ $\frac{-1}{h_{21}}$	$\frac{1}{g_{21}}$ $\frac{g_{22}}{g_{21}}$ $\frac{g_{11}}{g_{21}}$ $\frac{\Delta g}{g_{21}}$	A B C D	$\frac{d}{\Delta b}$ $\frac{b}{\Delta b}$ $\frac{c}{\Delta b}$ $\frac{a}{\Delta b}$

a	$\frac{z_{22}}{z_{12}}$	$\frac{\Delta z}{z_{12}}$	$\frac{-y_{11}}{y_{12}}$	$\frac{-1}{y_{12}}$	$\frac{1}{h_{12}}$	$\frac{h_{11}}{h_{12}}$	$\frac{-\Delta g}{g_{12}}$	$\frac{-g_{22}}{g_{12}}$	$\frac{D}{\Delta a}$	$\frac{B}{\Delta a}$	a	b
b												
c	$\frac{1}{z_{12}}$	$\frac{z_{11}}{z_{12}}$	$\frac{-\Delta y}{y_{12}}$	$\frac{-y_{22}}{y_{12}}$	$\frac{h_{22}}{h_{12}}$	$\frac{\Delta h}{h_{12}}$	$\frac{-g_{11}}{g_{12}}$	$\frac{-1}{g_{12}}$	$\frac{C}{\Delta a}$	$\frac{A}{\Delta a}$	c	d
d												

$\Delta z = z_{11}z_{22} - z_{12}z_{21}$; $\Delta y = y_{11}y_{22} - y_{12}y_{21}$

$\Delta h = h_{11}h_{22} - h_{12}h_{21}$; $\Delta g = g_{11}g_{22} - g_{12}g_{21}$

$\Delta a = AD - BC$; $\Delta b = ad - bc$

Chapter 7: Polynomial functions of $C_n(\omega)$ of a low-pass Chebyshev filter

Order n	Polynomial $C_n(\omega)$
0	1
1	ω
2	$2\omega^2 - 1$
3	$4\omega^3 - 3\omega$
4	$8\omega^4 - 8\omega^2 + 1$
5	$16\omega^5 - 20\omega^3 + 5\omega$
6	$32\omega^6 - 48\omega^4 + 18\omega^2 - 1$
7	$64\omega^7 - 112\omega^5 + 56\omega^3 - 7\omega$

End of paper.